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(54) Spin speed control means for laundry spin driers

(57) Spin speed control apparatus for a laundry spin drier includes sensing means 25 for monitoring a variable representing the cyclic dynamic loading imposed on the rotating drum 18 by an out-of-balance load of clothes in it during the spin cycle. The sensing means 25 is arranged to generate a signal indicative of the monitored variable having reached a predetermined value. Speed control means 44, 45, 47, 48 for the drum motor 16 is arranged to address and interrogate the sensing means 25 at successive increments of spin speed during the acceleration of the drum in the spin cycle and to respond to a signal generated by the sensing means at any one of the successive incremental speeds by controlling the motor 16 to continue to run at the then-prevailing speed or a lower constant speed.

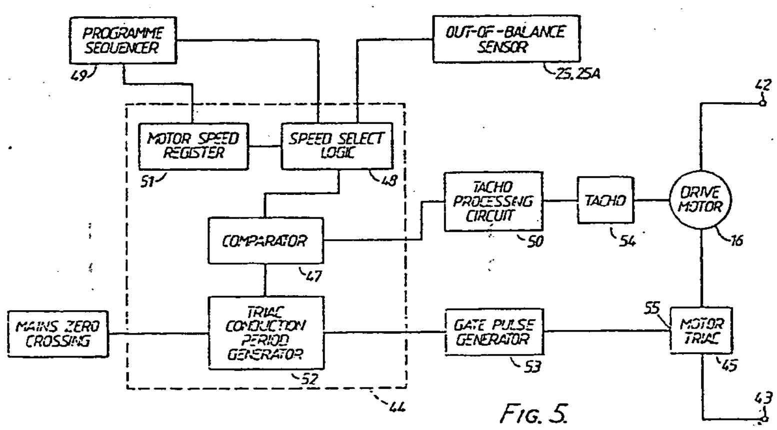

FIG. 5.

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The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.
The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1982.

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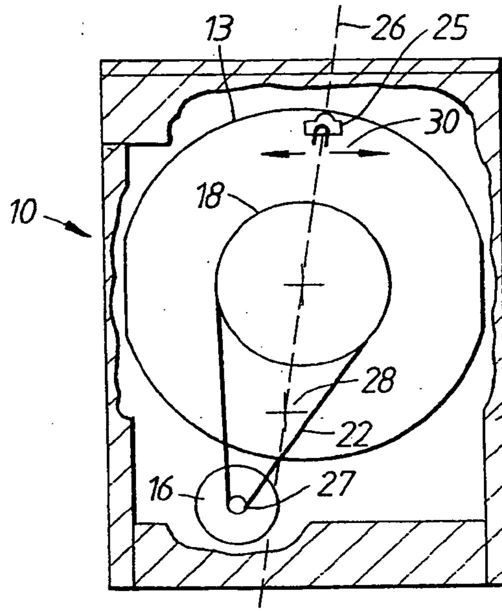

FIG. 1.

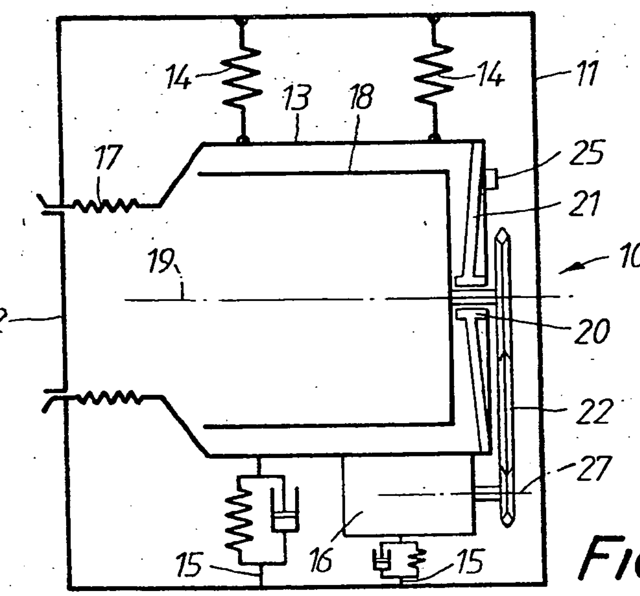

FIG. 2.

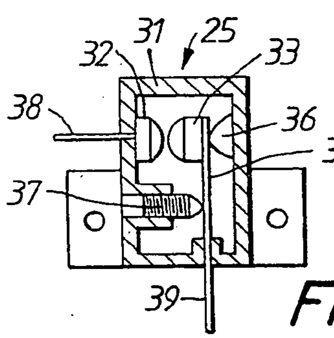

FIG. 3.

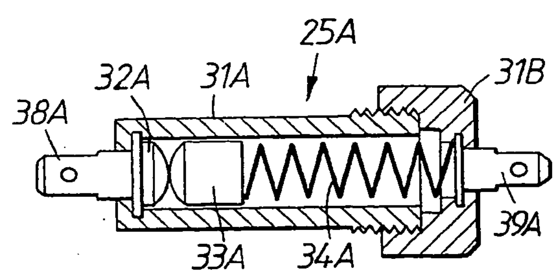

FIG. 4.

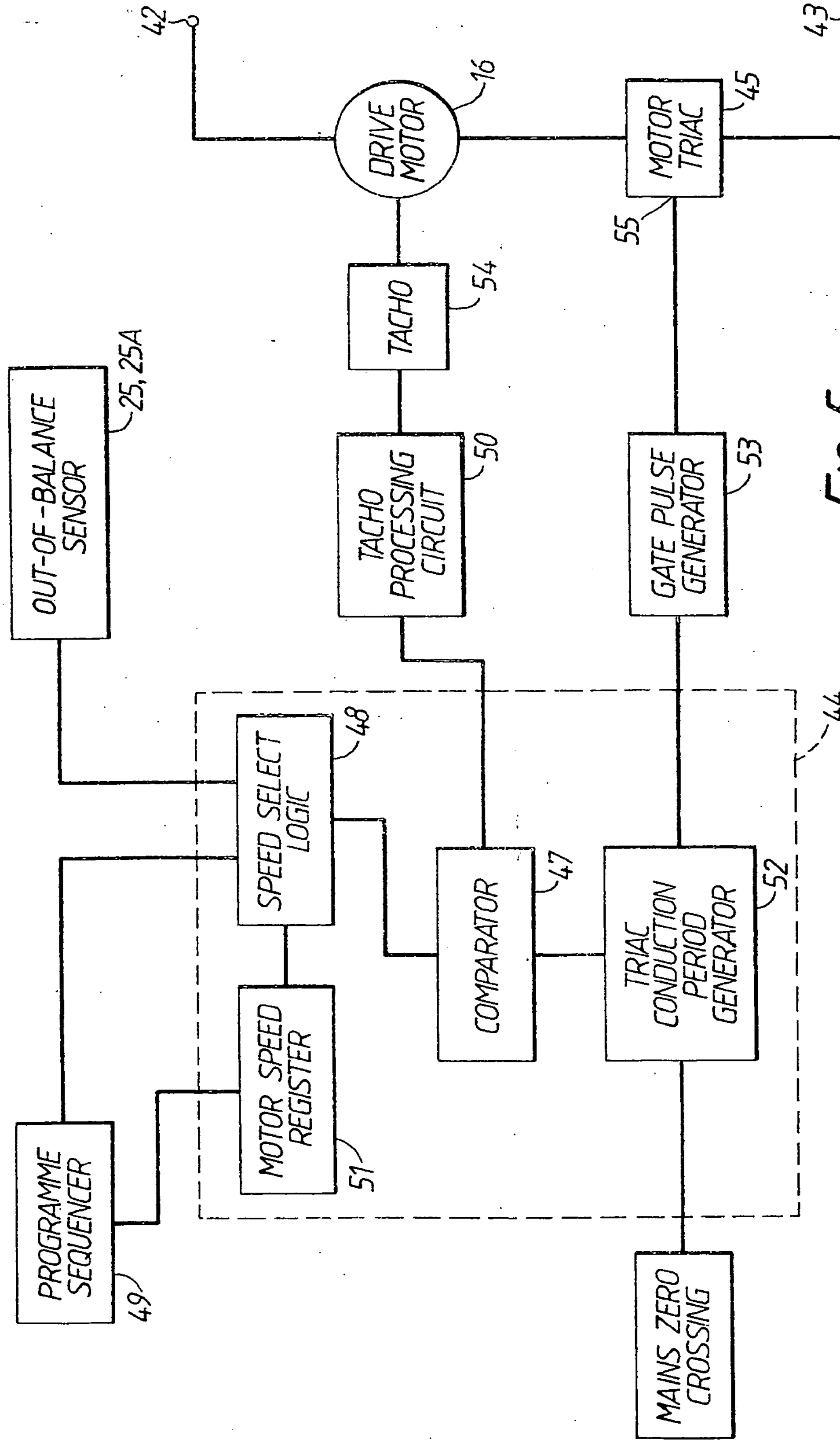
42
43
DRIVE MOTOR
16
MOTOR TRIAC
45
55
TACHO
54
OUT-OF-BALANCE SENSOR
25, 25A
TACHO PROCESSING CIRCUIT
50
GATE PULSE GENERATOR
53
44
SPEED SELECT LOGIC
48
COMPARATOR
47
TRIAC CONDUCTION PERIOD GENERATOR
52
MOTOR SPEED REGISTER
51
PROGRAMME SEQUENCER
49
MAINS ZERO CROSSING

FIG. 5.

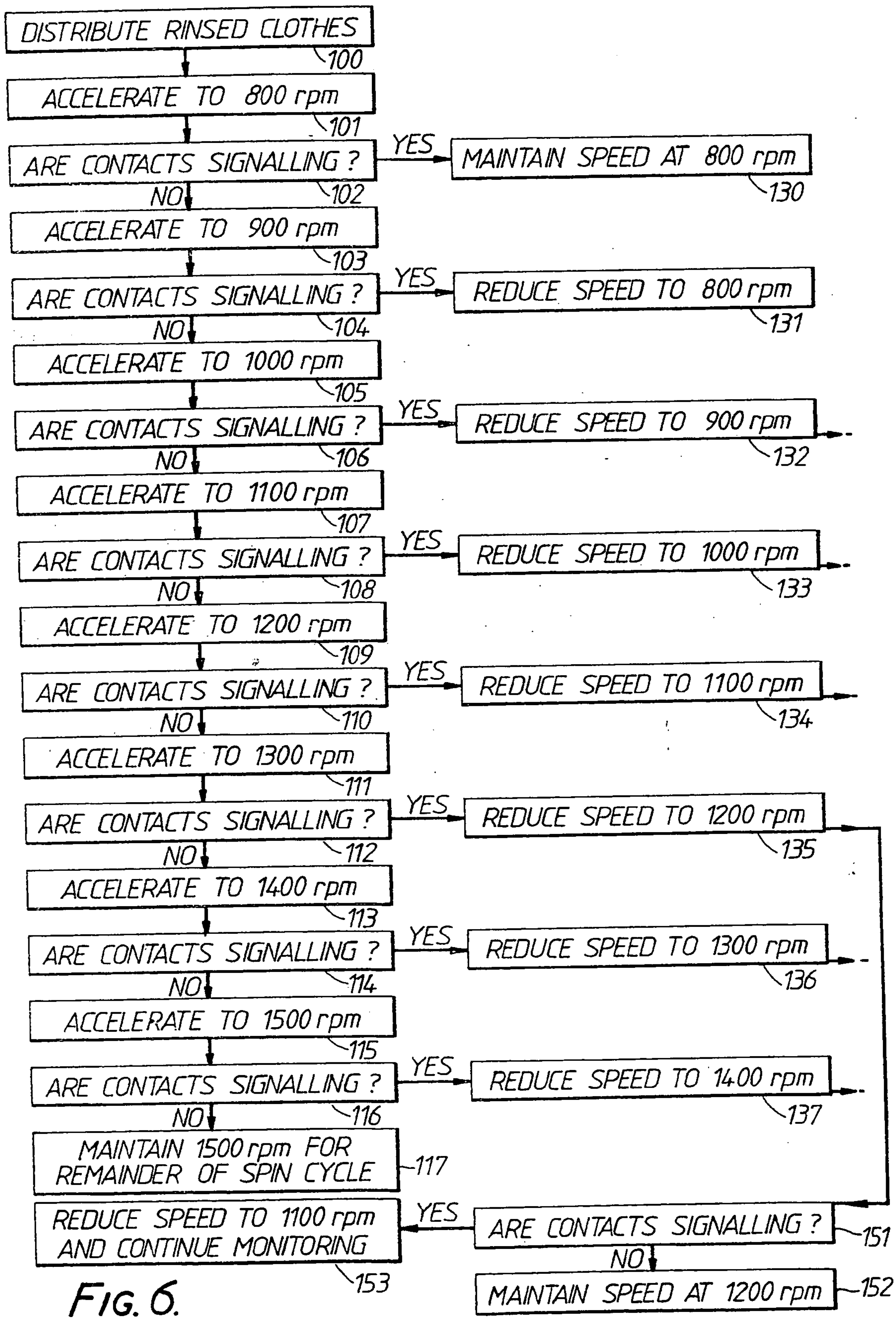
DISTRIBUTE RINSED CLOTHES
100
ACCELERATE TO 800 rpm
101
ARE CONTACTS SIGNALLING ?
102
YES
MAINTAIN SPEED AT 800 rpm
130
NO
ACCELERATE TO 900 rpm
103
ARE CONTACTS SIGNALLING ?
104
YES
REDUCE SPEED TO 800 rpm
131
NO
ACCELERATE TO 1000 rpm
105
ARE CONTACTS SIGNALLING ?
106
YES
REDUCE SPEED TO 900 rpm
132
NO
ACCELERATE TO 1100 rpm
107
ARE CONTACTS SIGNALLING ?
108
YES
REDUCE SPEED TO 1000 rpm
133
NO
ACCELERATE TO 1200 rpm
109
ARE CONTACTS SIGNALLING ?
110
YES
REDUCE SPEED TO 1100 rpm
134
NO
ACCELERATE TO 1300 rpm
111
ARE CONTACTS SIGNALLING ?
112
YES
REDUCE SPEED TO 1200 rpm
135
NO
ACCELERATE TO 1400 rpm
113
ARE CONTACTS SIGNALLING ?
114
YES
REDUCE SPEED TO 1300 rpm
136
NO
ACCELERATE TO 1500 rpm
115
ARE CONTACTS SIGNALLING ?
116
YES
REDUCE SPEED TO 1400 rpm
137
NO
MAINTAIN 1500 rpm FOR REMAINDER OF SPIN CYCLE
117
REDUCE SPEED TO 1100 rpm AND CONTINUE MONITORING
153
YES
ARE CONTACTS SIGNALLING ?
151
NO
MAINTAIN SPEED AT 1200 rpm
152

FIG. 6.

SPECIFICATION

Spin speed control means for laundry spin driers

This invention relates to spin speed control apparatus and methods for laundry spin driers, for example such as are incorporated in programme-controlled domestic clothes washing machines of the single-tub type.

Domestic clothes washing machines of the single-tub type frequently have a fixed outer housing or frame in which is resiliently supported a non-rotary tub which acts as a container for washing and rinsing water, and a rotary apertured drum journalled in and supported by the tub and driven by an electric motor at various controlled speeds, enabling programmed washing and rinsing cycles to be performed on a load of clothes inserted into the drum, these cycles being at low drum speeds, e.g. 45-55 r.p.m., followed by a relatively low speed distribution cycle, e.g. at 82 r.p.m., for distributing the wet clothes as uniformly as possible around the interior circumference of the drum pripr to a high speed spin cycle at a pre-selected drum spin speed for centrifuging the rinsing water from the clothes to leave the clothes in a damp condition suitable for rapid final drying.

If the wet clothes are not distributed sufficiently uniformly around the inner circumferential wall of the drum before the spin-dry cycle is started, the out-of-balance mass of wet clothes in the drum will impose a substantial unbalance cyclic dynamic loading on the drum supporting system during the spin cycle. At high spin speeds these unbalanced cyclic dynamic loadings will cause substantial vibrations and may impose considerable stresses on components of the machine such as the drum bearings, the tub spider by which these bearings are supported, and the tub suspension means, all of which have to be designed to withstand these cyclic loadings at maximum spin speed under the worst out-of-balance conditions. In addition, if the amplitude of these vibrations is excessive the oscillating tub assembly may strike the surrounding frame of the machine causing noise and possibly damage. Thus the maximum permitted spin speed has to be restricted to accommodate these extreme out-of-balance conditions in the drum, even though they will only be encountered in a minority of operations of the machine.

Various proposals have been made for restricting these out-of-balance dynamic loadings by monitoring some variable which is related to the degree of out-of-balance of the rotating drum load, and using the sensed variable to prevent excessive vibrations occuring during the spin cycle. For example, it has been proposed to monitor the current being taken by the drum motor during the spin cycle and to use the sensed value of the motor current for control of the spin speed.

An object of the invention is to provide an improved control system or method for preventing this dynamic out-of-balance loading from reaching an impermissibly high level during the spin cycle by sensing or monitoring a variable which represents that dynamic loading, which involves controlling the spin speed in a novel way in response to the said variable, for example by means of a microprocessor.

Accordingly the present invention from one aspect comprses apparatus for, and a method of, controlling the spin speed of a laundry spin drier or other centrifuge machine, by sensing at a predetermined spin speed a said variable representing the out-of-balance dynamic loading imposed on the drum by an unbalanced load therein during the spin cycle, and in the event of the sensing means indicating that the sensed variable has reached a certain predetermined peak value, by thereupon automatically regulating the drum speed to its then-prevailing value or to a lower constant speed value, or in the alternative event of the sensing means not so indicating, by thereupon automatically increasing the drum speed to a higher value.

The invention from another aspect comprises a method of, and apparatus for, sensing and monitoring the said variable representing the out-of-balance dynamic loading imposed on the drum during the spin cycle, by continuously or intermittently interrogating the output of the monitoring means during the angular acceleration of the drum after the start of the spin cycle, and in the event of the monitoring means indicating at a particular spin speed that the out-of-balance dynamic loading has reached a certain predetermined peak value, thereupon automatically regulating the motor speed to its then-prevailing speed or to a lower constant value.

In one form of the invention from this latter aspect, the monitoring means is interrogated intermittently at successive predetermined increments of spin speed during the spin cycle. In this case, the said regulation of the motor may either be to its then prevailing speed for the remainder of the spin cycle, or it may be to that corresponding to the preceding next-lower incremental spin speed.

If the motor regulation was to the speed corresponding to the preceding next-lower incremental spin speed, as mentioned, then either the motor speed may continue to be regulated to that lower spin speed for the remainder of the spin cycle, or the monitoring and interrogation may be continued at that lower spin speed and, in the event of the monitoring means still, or again, indicating the predetermined peak level of dynamic out-of-balance loading, the motor speed may then be reduced again to that corresponding to the next preceding, still-lower incremental spin speed. This latter monitoring and regulatory sequence cycle may be repeated as many times as is necessary to reduce the sensed out-of-balance loading to below the said predetermined peak level.

Thus the invention from another aspect comprises spin speed control apparatus for a laundry spin drier, which comprises sensing means for monitoring a variable representing the cyclic dymanic loading imposed on the rotating drum by an out-of-balance load of clothes in it during the spin cycle, the sensing means being arranged to generate a signal indicative of the monitored variable

having reached a predetermined peak value, and speed control means for the drum motor, the speed control means being arranged to address and interrogate the sensing means at successive increments of spin speed during the acceleration of the drum in the spin cycle, and to respond to a said signal generated by the sensing means at any one of the successive incremental speeds by controlling the motor to continue to run at the then-prevailing speed or a lower constant speed.

In one form of the invention from this last aspect, the motor speed control means is arranged to respond to the signal from the sensing means by maintaining the drum spin speed at the incremental speed then prevailing, or at a constant lower speed, for the remainder of the spin cycle.

As indicated above, in the case where in response to the signal the motor speed is controlled to a constant lower speed, the monitoring of acceleration may be continued at that lower speed so that in the event of a further sensor signal being received at that lower speed, the control means can be arranged to respond again and lower the spin speed to a still lower constant speed.

Conveniently the motor speed control means may incorporate a microprocessor.

The predetermined peak value of the sensed variable will be chosen as one corresponding to an out-of-balance dynamic loading which is known to be safe and acceptable for that particular machine, i.e. sufficiently below the 'breakage' value at which unacceptably large vibrations or noise would be produced and/or there would be risk of damage being caused by the dynamic loading. The control system ensures that once that predetermined peak value has been reached at a particular incremental drum speed during the spin cycle accleration, the motor is thereafter controlled either to that spin speed or to a constant lower speed, for example that corresponding to the next lower incremental speed.

The increments of drum spin speed may all be equal, for example steps of 100 r.p.m.

The variable to be monitored as representative of the cyclic dynamic out-of-balance loading may be chosen from several possibilities, such as the fluctuations in angular drum speed or motor speed, or in the current taken by the drum motor, caused by such out-of-balance, or the stress imposed on a component of the machine by the out-of-balance loading may be measured by means of a strain gauge.

However, according to an optional further feature of the invention, from any of the aforesaid aspects, where, as in the case of most single-tub domestic clothes washing machines, the centrifuge drum forms part of a resiliently-mounted assembly with an outer non-rotary tub in which the drum is rotatably mounted, the sensing and monitoring means may comprise means for directly sensing the oscillatory acceleration of the tub and drum assembly caused by an out-of-balance load in the rotating drum during the spin cycle, the said signal being indicative of the magnitude of the acceleration having reached a prdetermined peak value.

A control system incorporating such a means for sensing the oscillatory acceleration of the tub is the subject of our copending patent application No. 8511314 of even date, (Case 1288) which is incorporated by reference herein and a copy of whose specification is annexed hereto. In its preferred form that acceleration sensing means comprises an inertia-actuated electric switch.

As explained in our aforementioned copending application No. 8511314, the cyclic dynamic loading imposed on, and reacted to, by the drum and other components of the machine by an out-of-balance drum load may be taken as being proportional to the product of the out-of-balance mass and the square of the speed of drum rotation, and has an inverse relationship to the total mass of the rotating system. It has now been found by the inventor that a component in a plane perpendicular to the drum axis of the oscillatory acceleration of the resiliently-mounted tub and drum assembly caused by such unbalanced loading is directly representative of the magnitude of the dynamic loading imposed by the imbalance. The choice of this oscillatory acceleration of the resiliently-mounted assembly as the variable to be monitored ensures that the dynamic results of the unbalanced load are sensed directly near their source, in terms directly related to the dynamic imbalance, and a much more accurate control signal can be derived for controlling the spin speed, than would be possible for controlling the spin speed, than would be possible using such secondary variables as motor current or drum speed fluctuations.

While the invention has been described above in relation to laundry spin driers, and to domestic clothes washing machines incorporating spin dry cycles, it will be realised that it can equally well be applied to other forms of centrifuge for domestic, industrial, commercial or agricultural use.

Thus, according to the invention from yet another aspect, a method of controlling the spin speed of a centrifuge machine, for example a laundry spin drier, comprises monitoring a variable representative of the dynamic loading imposed on the rotating drum by an out-of-balance load in it during the spin cycle, by a sensing means arranged to generate a signal indicative of the monitored variable having reached a predetermined peak value, addressing and interrogating the sensing means at successive increments of spin speed during the acceleration of the drum in the spin cycle, to determine at each such incremental speed in turn whether or not the sensing means is generating a said signal, and if a signal is being generated, controlling the drum motor speed in response to that signal to cause the motor to continue to run at its then-prevailing speed, or at a lower constant speed; or if no signal is being generated, raising the spin speed by the next increment.

In this method, the sensing means may monitor the oscillatory accelerations of a resiliently-mounted assembly of the drum and a non-rotary outer housing, for example by means of an inertia-actuated electric switch.

In one form of this method the motor is controlled in response to a signal being generated by the addressed sensing means to continue to run at the incremental speed then prevailing, or at a constant lower speed, for the remainder of the spin cycle.

In another form of this method, in which the motor is controlled in response to a signal generated by the addressed sensing means to a constant lower speed, the monitoring and interrogation may then be continued, and if the addressed sensing means then still, or again, generates a said signal, the motor speed may be lowered in response to that signal by a further decrement of spin speed to the next-lower incremental spin speed level, and so on, as discussed above.

In another form of the method, however, the motor is controlled to reduce its speed from that prevailing when the addressed sensor is generated a signal, to the previous next-lower incremental speed, and then to repeat the address, interrogation, and incremental control sequence.

The invention may be carried into practice in various ways, but one specific embodiment and a modification thereof will now be specifically described by way of example only and with reference to the accompanying drawings, in which

Figures 1 and *2* are diagrammatic rear and side views of the interior of a single-tub clothes washing machine microprocessor motor spin control by tub oscillation acceleration sensing,

Figure 3 is a detail view of one form of inertia switch for use as the acceleration sensor for the machine of Figures 1 and 2,

Figure 4 shows an alternative form of inertia switch for use as the acceleration sensor,

Figure 5 is a block diagram showing the inter-relationship of the various components and functions of the control system used in the machine of Figures 1 and 2, and

Figure 6 is a flow-chart of the programme of control operations performed by the system of Figure 5 in a spin cycle.

Figures 1 and 2 show a programme-controlled single-tub domestic clothes washing machine 10 with a high-speed spin-dry facility. The machine 10 has an outer frame or housing 11 which is floor-standing and is provided with a door 12 in its front wall. A non-rotary tub 13 is suspended in the housing 11 by means of spring suspension units 14 and damper struts 15, and supports an electric motor 16 on its lower external side. The mouth of the tub is resiliently sealed to the frame of the door 12 by a bellows 17. A rotary perforated centrifuge drum 18 is journalled with its axis 19 horizontal in bearings 20 supported by a spider 21 secured to the rear wall of the tub 13, and the motor shaft 27 is coupled to the shaft of the drum 18 by means of a speed-reducing belt-and-pulley transmission 22. An out-of-balance acceleration sensor 25 in the form of an inertia switch is mounted on the upper exterior of the tub 13 in a position shown close to, but preferably lying in, a plane 26 containing the drum shaft axis 19 and the centre of gravity 28 of the suspended system, and on the side of the drum shaft axis 19 remote from the centre of gravity.

The sensor 25 is mounted on the tub 13 to sense and respond to components of the tub oscillating acceleration in the horizontal direction shown by the double-headed arrow 30 in Figure 1, in a plane perpendicular to the drum axis of rotation 19. The sensor 25 comprises an inertia switch, one construction of which is illustrated in Figure 3. As shown the switch 25 of Figure 3 comprises a housing 31 supporting a fixed contact 32. A cooperating movable contact 33 is mounted on the upper end of a leaf spring conductor 34 whose lower end is fixed in the housing wall and which is arranged to bias the moving contact 33 away from the fixed contact 32 and against a back stop 36. An adjustment screw 37 is provided as shown in the housing wall for cooperation with the leaf spring 34 for contact adjustment if necessary. The switch terminals are shown at 38,39. The switch 25 is mounted on the tub 13 with the length of the leaf spring perpendicular to the arrow 27 in Figure 1, and with the centre line (not shown) of the two contacts 32,33 parallel to the arrow 27, i.e. so that it can respond to horizontal components of acceleration of the tub in the direction of arrow 27 by closing the normally-open contacts 32,33. The mass of the movable contact 33 and the strength of the leaf spring 34 are so chosen that the contact 33 will just move into closing engagement with the fixed contact 32 to close the switch in response to a predetermined peak acceleration value, and will separate again from contact 32 under the action of the spring 34 very shortly after closing. In this particular machine this peak value of acceleration is chosen to be about 15 g, which is roughly half of the 'breakage' value at which damage to the bearing or other parts of the machine is likely to occur.

Figure 4 shows an alternative form of inertia switch 25A which may be used instead of the normally-open switch 25. This is a normally-closed switch whose moving contact 33A is slidable in a cylindrical housing 31A provided with a screw cap 31B, the moving contact being biassed by a coil spring 34A into engagement with a fixed contact 32A at the end of the cylinder remote from the cap 31B. The switch terminals are shown at 38A and 39A. The switch would be set to just open under an applied acceleration of 15g, which would be created by an out-of-balance mass of 1 kg at a spin speed of 1100 r.p.m. This form of normally-closed switch 25A may be found preferably in the present system, as it is likely to have a longer life and greater reliability, with less risk of malfunction due to contact erosion, and contact pressure in the normally-closed state being high.

Figure 5 shows the control system in block diagram form. The motor 16 which drives the drum 18 is for example a series-would a.c. commutator motor, whose, speed is controlled by varying the firing angle of a series-connected triac 45. The motor supply terminals are shown at 42 and 43. A microprocessor indicated by the broken-line rectangle 44 is used to control the firing of the triac and hence the speed of the motor. The microprocessor includes a comparator 47 which compares a speed

demand signal from the speed select logic 48 with a measured speed signal supplied from the motor shaft tachometer 54 via processing circuitry 50. The speed select logic 48 addresses the out-of-balance sensor switch 25 or 25A as well as the motor speed register 51 (which stores values in increments of spin speed of 100 r.p.m.) and the programme sequencer 49. The comparator output is to the triac conduction period generator 52, and thence via the gate pulse generator 53 to the control electrode 55 of the motor triac 45.

The sequence of logic steps controlled by the microprocessor is shown diagrammatically in Figure 6. The operation of the system will now be described with particular reference to that figure. Reference 100 in Figure 6 indicates the low-speed distribution cycle, which is performed at say 82 r.p.m. under the control of the sequencer 49 to distribute the washed and rinsed clothes as uniformly as possibly around the interior circumference of the drum 18. On conclusion of the distribution cycle the spin cycle is started from that low speed (e.g. 82 r.p.m.) or from zero drum speed, and the motor 16 accelerates the drum. When a drum speed of 800 r.p.m. has been reached, reference 101, the microprocessor 46 addresses and interrogates the inertia switch 25 or 25A to see (reference 102) whether its contacts 32,33 or 32A,33A, are closing/opening to provide a signal. As indicated above, so long as the acceleration of the tub 13 and drum 18 assembly due to any out-of-balance in the drum load is below the predetermined peak value (15g) known to be safe, the switch 25,25A will remain open/closed. If however the dynamic loading is excessive, giving rise to accelerations above that predetermined value at 800 r.p.m., the contacts 32,33 of the inertia switch will just close (or just open in the case of the contacts 32A,33A of the normally-closed switch 25A), and therefore the contacts will continue to open and close in synchronism with the cyclic acceleration to the tub. This opening and closing of the contacts is a signal recognised by the speed select logic 48 of the microprocessor, which will then control the motor speed to a maintained drum speed value of 800 r.p.m. (reference 130) for the remainder of the spin cycle.

If however when the switch 25,25A is addressed at 800 r.p.m. (reference 102) there is no signal to be detected by the microprocessor because the out-of-balance acceleration has not reached the predetermined safe value, the microprocessor then raises the motor speed to a spin speed of 900 r.p.m., i.e. an increment of 100 r.p.m. (reference 103). At that incremental speed the microprocessor again interrogates the switch 25 or 25A to determine whether there is a signal (reference 104). If there is not, the microprocessor will increase the motor speed to reach a drum spin speed of 1000 r.p.m., a further increment of 100 r.p.m. (reference 105). If, however, there is a signal at reference 104, indicating that the predetermined acceleration value has been reached due to an imbalance in the drum load, then the microprocessor will respond to the signal by at once reducing the motor speed to the previous incremental drum speed of 800 r.p.m. (reference 131).

The acceleration monitoring and the interrogation of the inertia switch output by the microprocessor is continued after a spin speed reduction to any incremental speed in excess of 800 r.p.m., and in the event of a switch signal being detected at that reduced incremental speed, indicating that the suspended assembly acceleration is still, or is onc more, at or above the predetermined peak value, the microprocessor is arranged to reduce the motor speed by one or more further decrements of 100 r.p.m. spin speed, until no switch signal is detected.

This is shown diagrammatically in Figure 6 for the block 135 only, where the speed has been reduced by 100 r.p.m. to 1200 r.p.m. If the contacts do not signal at that spin speed, (reference 151) the spin speed is maintained at 1200 r.p.m. for the remainder of the spin cycle (reference 152). If however the contacts continue to signal, or again start signalling, in block 151 at 1200 r.p.m., then the spin speed is further reduced by 100 r.p.m. to 1100 r.p.m. (reference 153). This sequence cycle will be repeated as many times as necessary, cascading the spin speed down through successive decrements of 100 r.p.m., until no contact signal is detected and the speed then reached will be maintained.

Figure 6 shows these further interrogation and response sequences starting at the reduced incremental speed of 1200 r.p.m. (reference 135) only, but it will be understood that they will take place similarly at each reduced incremental speed above 800 r.p.m. (reference 132-137), the speed being reduced by a further decrement of 100 r.p.m. each time a signal is sensed.

It will be seen from Figure 6 that the microprocessor programme can continue step by step from that stage, successively raising the drum speed by increments of 100 r.p.m. and interrogating the switch at each incremental speed (references 101 to 117), and that if no signal occurs at any of these incremental speeds the drum speed can be raised to the maximum available value, in this case 1500 r.p.m. (reference 115) and maintained at that maximum speed for the remainder of the spin cycle. If, however, at any incremental speed above 800 r.p.m. the microprocessor detects a signal, it will thereupon reduce the drum speed by one or more decrements of 100 r.p.m. until no signal is detected, thus ensuring that the predetermined value of the out-of-balance acceleration is not exceeded for that particular degree of load imbalance as a result of too high a spin speed.

The form of spin speed control provided by the system described makes it possible to uprate a standard washing machine to a higher maximum available spin speed than would otherwise be safe under conditions of serious load imbalance in the drum, since the control system ensures that for any possible degree of drum load imbalance the drum spin speed will always be controlled so that it does not exceed the value corresponding to a predetermined degre of dynamic out-of-balance

stressing known to be safe. In most drum loads which are well distributed and more or less in balance, the system automatically allows a high spin speed, and in many cases the maximum available spin speed of 1500 r.p.m., to be used.

As well as ensuring that the spin speed is always restricted to the maximum allowable for the particular clothes load involved, the control system described and illustrated has other advantages. It is simple and inexpensive to manufacture and install. It enables the maximum available spin speed of a particular washing machine to be safely increased without the necessity for increasing the strength of existing components of the machine that are subject to the dynamic out-of-balance stressing. The response provided by an inertia control type of acceleration sensor is directly related to the out-of-balance stresses which produce those accelerations, as contrasted with possible arrangements in which a secondary parameter such as fluctuating motor current or drum speed is sensed. Motor design is simplified since it is no longer necessary to design into the motor means for dropping the high motor speed at high out-of-balance loading. Contact wear in the inertia switch is minimised, as the contact pressure is practically zero at make-and-break, so that considerably longer contact life should be achieved than is usual in microswitches and relays.

If the normally-open inertia switch 25 is provided with a second fixed contact behind the moving contact 33, in place of the back stop 36, this could be arranged to be contacted by the moving contact to provide a signal to the microprocessor, or to some additional emergency circuit, to stop the motor drive and switch the machine off altogether, in the event of exceptionally great tub acceleration being sensed due to some fault in the system.

The use of a normally-closed inertia switch such as that shown in Figure 4 may also provide the system with a fail-safe characteristic, since in the event of a lead to the switch becoming inadvertently disconnected or broken in use, or of a breakage of the biasing spring of the movable contact, the microprocessor may be arranged to respond to the resultant loss of output voltage from the switch by automatically controlling the spin speed to a lower preset value, for example 500 r.p.m. or to zero.

The spin speed control system of the present invention is designed to operate at spin speeds during the spin cycle itself, and to prevent excessive dynamic stressing of the machine during the spin cycle due to out-of-balance loading of the drum. There is, however, another form of dynamic disturbance to which spin driers are liable, and that is a large-amplitude low-frequency oscillation of the tub/drum assembly which may occur at a quite low critical drum speed shortly after the drum has started to rotate, due to resonance with the natural frequency of the tub/drum suspension system.

However, according to a further optional feature of the present invention, a washing machine or spin drier may be provided with a first sensor means for monitoring a variable representing the cyclic dynamic loading imposed on the drum during the spin cycle, and associated speed control means for interrogating the sensor and controlling the drum spin speed during the spin cycle if any of the ways discussed above, and with a second sensor, e.g. an inertia switch, responsive to the low-speed resonance oscillation at the critical low speed just referred to. This second sensor may operate means arranged to abort the prospective spin cycle and initiate a further distribution cycle, with a view to achieving a better-balanced distribution of the load in the drum before starting the high-speed spin cycle; or it may be used to stop the machine altogether so as to allow manual redistribution of the load in the drum.

CLAIMS

1. A method of controlling the spin speed of a laundry spin drier or other centrifuge machine, which comprises sensing at a predetermined spin speed a said variable representing the out-of-balance dynamic loading imposed on the drum by an unbalanced load therein during the spin cycle, and in the event of the sensing means indicating that the sensed variable has reached a certain predetermined peak value, thereupon automatically regulating the drum speed to its then-prevailing value or to a lower constant speed value, or in the alternative event of the sensing means not so indicating, thereupon automatically increasing the drum speed to a higher value.

2. A method of controlling the spin speed of a laundry spin drier or other centrifuge machine which comprises sensing and monitoring the said variable representing the out-of-balance dynamic loading imposed on the drum during the spin cycle, by continuously or intermittently interrogating the output of the monitoring means during the angular acceleration of the drum after the start of the spin cycle, and in the event of the monitoring means indicating at a particular spin speed that the out-of-balance dynamic loading has reached a certain predetermined peak value, thereupon automatically regulating the motor speed to its then-prevailing speed or to a lower constant value.

3. A method as claimed in claim 2 in which the monitoring means is interrogated intermittently at successive predetermined increments of spin speed during the spin cycle.

4. A method as claimed in claim 3 in which the said increments of spin speed are all equal.

5. A method as claimed in claim 3 or claim 4, in which the said regulation of the motor is to its then-prevailing speed for the remainder of the spin cycle.

6. A method as claimed in claim 3 or claim 4, in which the said regulation of the motor is to that corresponding to the preceding next-lower incremental spin speed.

7. A method as claimed in claim 6 in which the said regulations to the next-lower incremental spin speed is continued for the remainder of the spin cycle.

8. A method as claimed in claim 6 in which the

monitoring and interrogation is continued at that lower spin speed and, in the event of the monitoring means still, or again, indicating the predetermined peak level of dynamic out-of-balance loading, the motor speed is then reduced again to that corresponding to the next preceding, still-lower incremental spin speed, this latter monitoring and regulatory sequence cycle being repeated as many times as is necessary to reduce the sensed out-of-balance loading to below the said predetermined peak level.

9. Spin speed control apparatus for a laundry spin drier, which comprises sensing means for monitoring a variable representing the cyclic dynamic loading imposed on the rotating drum by an out-of-balance load of clothes in it during the spin cycle, the sensing means being arranged to generate a signal indicative of the monitored variable being reached a predetermined peak value, and speed control means for the drum motor, the speed control means being arranged to address and interrogate the sensing means at successive increments of spin speed during the acceleration of the drum in the spin cycle, and to respond to a said signal generated by the sensing means at any one of the successive incremental speeds by controlling the motor to continue to run at the then-prevailing speed or a lower constant speed.

10. Apparatus as claimed in claim 9 in which the said increments of spin speed are all equal.

11. Apparatus as claimed in claim 9 or claim 10 in which the motor speed control means is arranged to respond to the signal from the sensing means by maintaining the drum spin speed at the incremental speed then prevailing, or at a constant lower speed, for the remainder of the spin cycle.

12. Apparatus as claimed in claim 9 or claim 10, in which the motor speed control means is arranged to respond to the signal from the sensing means by controlling the motor speed to a constant lower speed, and the apparatus is constructed and arranged to continue the monitoring of acceleration at that lower speed so that in the event of a further sensor signal being received at that lower speed, the control means will respond again and lower the speed to a still lower constant speed.

13. Apparatus as claimed in any one of claims 8 to 12 in which the motor speed control means incorporates a microprocessor.

14. A method as claimed in any one of claims 1 to 8, for use with a machine whose centrifuge drum forms part of a resiliently-mounted assembly with an outer non-rotary tub in which the drum is rotatably mounted, in which the variable sensed is the oscillatory accelerations of the tub and drum assembly caused by an out-of-balance load in the rotating drum during the spin cycle.

15. Apparatus as claimed in any one of claims 8 to 13, for use with a machine whose centrifuge drum forms part of a resiliently-mounted ass mbly with an outer non-rotary tub in which the drum is rotatably mounted, in which apparatus the sensing means comprises means for directly sensing the oscillatory acceleration of the tub and drum assembly caused by an out-of-balance load in the rotating drum during the spin cycle.

16. Apparatus as claimed in claim 15, in which the sensing means comprises an inertia switch, mounted on the tub of the assembly.

17. A method of controlling the spin speed of a centrifuge machine, for example a laundry spin drier, which comprises monitoring a variable representative of the dynamic loading imposed on the rotating drum by an out-of-balance load in it during the spin cycle, by a sensing means arranged to generate a signal indicative of the monitored variable having reached a predetermined peak value, addressing and interrogating the sensing means at successive increments of spin speed during the acceleration of the drum in the spin cycle, to determine at each such incremental speed in turn whether or not the sensing means is generating a said signal, and if a signal is being generated, controlling the drum motor speed in response to that signal to cause the motor to continue to run at its then-prevailing speed, or at a lower constant speed; or if no signal is being generated, raising the spin speed by the next increment.

18. A method as claimed in claim 17 in which the sensing means monitors the oscillatory accelerations of a resiliently-mounted assembly of the drum and a non-rotary outer housing, for example by means of an inertia-actuated electric switch.

19. A method as claimed in claim 17 or claim 18 in which the motor is controlled in response to a signal being generated by the addressed sensing means to continue to run at the incremental speed then prevailing, or at a constant lower speed, for the remainder of the spin cycle.

20. A method as claimed in claim 17 or claim 18 in which the motor is controlled in response to a signal generated by the addressed sensing means to a constant lower speed and in which the monitoring and interrogation is then continued, and if the addressed sensing means then still, or again, generates a said signal, the motor speed is then lowered in response to that signal by a further decrement of spin speed to the next-lower incremental spin speed level.

21. A method as claimed in claim 17 or claim 18 in which the motor is controlled to reduce its speed from that prevailing when the addressed sensor is generating a signal, to the previous next-lower incremental speed, and the address, interrogation, and incremental control sequence is then repeated.

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